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MARKETS AND THE USE OF WILD ANIMALS FOR TRADITIONAL MEDICINE: A CASE STUDY AMONG THE TSIMANE' AMERINDIANS OF THE BOLIVIAN RAIN FOREST

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ABSTRACT.—The use of animal parts for traditional medicine is growing in Africa and developed nations of Asia, and persists among African and Asian immigrants in developed nations. The practice undermines wildlife conservation. We contribute to studies of the use of wild animals for traditional medicine by: 1) focusing on an Amerindian society (Tsimane') in the rain forest of Bolivia, 2) using a large sample (n = 508) of households selected at random, and 3) using multivariate regressions to test hypotheses about how markets affect the use of wild animals for traditional medicine. We find that the average adult uses only a few wild animals and obtains only a few parts to treat only a few human ailments. Markets exert unclear effects on people's use of wild animals for traditional medicine. Some proxies of markets (e.g., wages) correlate with a lower probability of using animals for medicine, but other proxies (e.g., cash income) correlate with a higher probability. Animal abundance in the village, income, and prices for modern medicines correlate with a higher probability of using animals. In the Bolivian rain forest, the use of animals for traditional medicine does not threaten conservation as it does elsewhere in the world.

Key words: medicines, Amerindians, animals, Tsimane', Bolivia.

RESUMEN.—El uso de animales para medicina tradicional está creciendo en África y en los países desarrollados de Asia, y persiste entre los inmigrantes asiáticos y africanos que viven en países desarrollados. Esta práctica daña la conservación de la vida silvestre. Este artículo contribuye a la investigación sobre el uso de animales silvestres para medicina tradicional porque 1) estudia una sociedad amerindia (los Tsimane') en la selva tropical de Bolivia, 2) utiliza una gran muestra de hogares seleccionados al azar (n = 508), y 3) usa regresiones multivariables para comprobar hipótesis sobre el efecto del mercado en el uso de animales como medicina tradicional. Los resultados muestran que típicamente un adulto usa pocas partes de pocos animales silvestres para tratar pocas enfermedades humanas. El mercado ejerce un efecto ambiguo en el uso de animales para medicina tradicional. Algunos estimadores del mercado (e.g., el salario) se correlacionan con una menor probabilidad de usar animales para medicina, mientras que otros estimadores (e.g., los ingresos monetarios) se correlacionan con una mayor probabilidad. La abundancia de animales en la comunidad, los precios de las medicinas modernas, así como salarios correlacionan con una mayor probabilidad de usar animales. En la selva tropical de Bolivia, el uso de animales para medicina tradicional no representa una amenaza para la conservación, como ocurre en otras partes del mundo.

RÉSUMÉ.—L'utilisation de parties animales dans la fabrication de remèdes traditionnels augmente en Afrique et dans les pays en développement d'Asie, et persiste parmi les immigrants asiatiques et africains habitant dans les pays développés. Cette pratique porte atteinte aux efforts de protection de la faune sauvage. Pour cette étude nous avons suivi la démarche suivante: 1) travail centré sur une société amérindienne (les Tsimane') dans la forêt tropicale bolivienne, 2) utilisation d'un large échantillon de foyers sélectionnés au hasard (n = 508), et 3) utilisation de régressions à plusieurs variables pour vérifier les hypothèses concernant l'effet des marchés sur l'utilisation d'animaux sauvages dans la médecine traditionnelle. Les résultats montrent qu'un adulte moyen n'utilise que peu d'animaux sauvages, et seulement quelques parties de l'animal, pour quelques maladies seulement. Le marché exerce un effet incertain sur l'utilisation d'animaux dans la fabrication de remèdes traditionnels. Certains estimateurs du marché (ex: les salaires) correspondent à une probabilité inférieure, d'autres (ex: revenus en espèces) à une probabilité plus élevée. Dans les communautés où les animaux sont abondants, les salaires bas, et le prix des médicaments modernes élevés, la probabilité est plus grande. Dans la forêt tropicale de Bolivie, contrairement à d'autres régions du monde, l'utilisation de parties animales dans la fabrication de remèdes traditionnels ne représente pas une menace pour la conservation de la faune.

INTRODUCTION

Amerindian societies in the tropical rain forests use a wide range of native plants to treat human ailments (Reyes-García 2001), but there is limited evidence to suggest that they also use wild animals to treat human ailments. Costa-Neto and his colleagues have documented the widespread use of fish, insects, and terrestrial animals to treat human ailments among fishermen and town dwellers in the semi-arid regions of northeast Brazil (Costa-Neto 1998; Costa-Neto and Marques 2000; Costa-Neto and Oliveira 2000). As part of a broader study on social integration among the Kiriri Indians of the semi-arid zone of the state of Bahia, Brazil, Bandeira (1972) found that the Kiriri used only 13 animals for medicine. Alexiades (1999) found that the Esse Eja Indians in the tropical rain forest of southern Peru used about 50 animal species for medicine.

In a recent comparative study among four lowland Amerindian groups, Wilkie and Godoy (2001) show that as incomes increased, consumption of fish declined, but consumption of terrestrial game rose and then fell, overshadowed by the increasing consumption of meat from domesticated animals. At higher levels of income, Amerindians switched to domesticated animals for most of their animal proteins. Here we build on this prior line of research and ask: "How does integration into a cash market economy with a consequent rise in cash income among households of tropical lowland Amerindians affect their traditional use of wild animals to treat human ailments?"

The question of how integration into a market economy affects the use of wild animals for traditional medicine has implications for conservation policy. If integration into the cash market reduces the human use of wild animals for traditional medicine, game conservation will improve, but if greater participation in a cash market economy increases the use of wild animals for medicines, conservation will worsen.

Most studies of the use of wild animals for traditional medicine have been done in Asia or in Africa. Studies by Bolze et al. (1998), Servheen (1993, 1996), Callister and Bythewood (1997), Marshall (1998), Kritsky (1987), Mainka and Mills (1995), and Banks (1998) suggest that the expansion of markets induces people to make greater use of wild animals for traditional medicine and that the practice has spread in developed nations of Asia and the Pacific (e.g., Taiwan, Australia). But other research suggests that the increasing use of animals for traditional medicine can also take place without economic prosperity. For example, Kritsky (1987) says that the use of insects for traditional medicine in China increased during the Cultural Revolution. Based on an ethnozoological survey of the use of medicinal birds, Joseph (1990) concludes that the use of birds to treat human ailments increased in Madhya Pradesh, Central India, because people could not afford modern treatments.

To help explain the conflicting findings we draw on a supply-demand framework from microeconomics. To answer the query of how markets affect the use of animal parts, we use information from a relatively large sample of households (n = 508) and villages (n = 59) of Tsimane' Amerindians, a society of horticulturalists and foragers in the tropical rain forest of the Bolivian lowlands. In working with a large sample, we avoid inaccuracies from a small sample. We also avoid the bias of relying on traditional medical experts who may not know how the rest of the population uses wild animals.

Our goal is to estimate how various direct indicators of integration into a cash market economy—such as cash income, distance to the nearest town, and modern forms of human capital such as literacy and schooling—affect the probability that people will use wild animals for traditional medicine. We omit domesticated animals from the analysis because the policy debate in conservation centers on how the human use of wild animals for traditional medicine affects conservation (Brautigam et al. 1994; Huxtable 1992; Khoshoo 1997; Malik et al. 1996; Pui-Hay But 1995).

Animals and animal parts are heterogeneous commodities. Integration into the cash market economy can increase the demand for some animals but not for others, and it can increase the demand for some animal parts but not for other parts. We estimate the correlation of a household's cash income, wealth, and various other indicators of integration to the market, and the age, gender, and size of the household head with the household's use of wild animals for traditional medicine.

We recognize three different effects on the use of wild animal parts for traditional medicine resulting from a change in cash income. We call the animal part a "superior" good if a one-percent rise in cash income increases consumption of the animal part by more than one percent. We call the animal part "normal" if a one-percent rise in cash income increases the consumption of animal parts for traditional medicine by less than one percent. We call the animal part "inferior" if a one-percent rise in cash income reduces consumption of animal parts because people seek other treatments.

An increase in income could increase demand for parts of an animal, but it could also lower demand for parts of another animal, producing an unclear net effect on conservation. An animal part might be a normal good when people have low income, but it might become an inferior good when people have higher income.

Other factors besides income may change the use of wild animals for traditional medicine. A greater abundance of wild animals in a community might reduce the costs of extracting animals for traditional medicines; if their use is limited by cost, then it will rise with increased abundance. If people view modern and traditional medicines as substitutes for each other, then a rise in the price of modern medicines should cause an increase in the use of traditional medicine. If people use modern and traditional medicines together, then a rise in the price of modern medicines should cause a decrease in the use of both medicines. The last case is a theoretical possibility; we do not know of any empirical case supporting this point.

ETHNOGRAPHIC SETTING

The Tsimane' are a foraging and horticultural Amerindian society of approximately 7,000 people living in about 100 villages in the rain forests at the eastern foothills of the Bolivian Andes in the Ballivián and Yacuma provinces of the department of Beni (Ellis 1996; Godoy 2001; Government of Bolivia 1995; Huanca 2000; Reyes-García 2001). The Tsimane' are culturally and historically related to the Mosetene Amerindians, who form part of the Awaruna linguistic group (Reyes-García 2001). Tsimane' villages are spread over several parks and political jurisdictions, including the Pilón-Lajas Biosphere Reserve, the Parque Nacional Isiboro-Sécure, Territorio Multiétnico, and Territorio Uno.

Tsimane' villages are typically inhabited only by Tsimane'. The villages surveyed were in Territorio Uno (along the river Maniqui and along the dirt road linking the towns of San Borja and Yucumo), Territorio Multiétnico, and in the Pilón Lajas Biosphere Reserve. Transport in the region is along the river and by footpaths in the forests. Several logging roads cut across the Tsimane' territory. During the rainy season travel by roads is slower; at that time, logging roads and even public roads linking different towns in the department of Beni become impassable.

The Tsimane' territory spreads from the foothills of the Andes to the northeast, reaching the edges of the Moxos savanna (14°35′–15°30′ south latitude;

66°23′–67°10′ west longitude). Habitats in Tsimane' territory range from wet to moist subtropical and gallery forest; some of their territory abuts savannas (Miranda 1995). Some Tsimane' inhabit areas of tropical rain forest at the foothills of the Andes, about 500 meters above sea level. Other Tsimane' communities are in moist forest in the savanna region at 150–250 meters above sea level. This type of forest is similar to Amazonian wet forest but is less diverse and lacks some of its typical species such as rubber (*Hevea brasiliensis* (Willd.ex Adr.Juss.) Muell.Arg.) or brazilnut (*Bertholletia excelsa* Humb. and Bonpl.). Drainage is deficient in the area owing to low variation in relief.

Part of the Tsimane' habitat is made up of savanna, which is found in areas with alluvial soils. The floristic composition of the savanna changes with relief and flooding. In the plains, the main vegetative formation is flooded forest with relatively low tree diversity, probably because of low pH soils with limited availability of nutrients (Killeen et al. 1993). Poaceae and Cyperaceae (grasses and sedges) predominate on the savannas of lower altitude and are used as natural forage for cattle. Islands of forest occur with more frequency in the savannas of higher elevation (Killeen et al. 1993). The climate of the Tsimane' area is moist, with a 4–5 month dry season (May to September). During one 15-month period of research, the average temperature was 26°C, ranging from a minimum of 10°C during May–June, when cold winds, locally called "Sur," arrive from the south, up to 42°C during August. The mean maximum temperature was 32°C, the mean minimum temperature was 20°C, and the average annual precipitation was 1,924 mm.

Tsimane' show large variation in social, educational, and economic attributes. Some Tsimane' in the upper Maniqui river are nomadic, live in small communities without schools, are monolingual in Tsimane', and rely on shifting cultivation, hunting, fishing, plant foraging, and barter of forest products. Down the river Maniqui, close to the town of San Borja (pop. approx. 16,000), Tsimane' are bilingual in Tsimane' and Spanish, live in large settlements reachable by road, and are more likely to live in villages with schools (Reyes-García 2001). Besides subsistence agriculture and foraging, Tsimane' in modern villages also work for wages and grow rice as a cash crop.

METHODS

The quantitative information for the analysis comes from a survey done between June and November 2000 among 508 households in 59 Tsimane' villages in the department of Beni. During May and June 2000 we tested the survey in Tsimane' communities close to the town of San Borja. The design and the administration of the survey drew on and were informed by a year of fieldwork by five researchers in two communities, one close (San Antonio) and one far (Yaranda) from the town of San Borja, during 1.5 years.

For the survey, we selected villages in the main Tsimane' regions, including the Pilón-Lajas Reserve, Territorio Multiétnico, and Territorio Uno. In each region, we selected villages close and far from towns and villages in between. In each village, we first did a population census of all households, assigned a number to each household in the village, wrote each number on a piece of paper, and we then selected numbers at random from the folded pieces of paper to decide which households to interview. If the household chosen was absent, we picked another number. In each village, we surveyed between 12 and 15 households. Once we had selected a household, we flipped a coin to decide whether to interview the female or the male household head. According to the census of lowland Bolivian Indians, most indigenous households are nuclear (76%) or extended (22%) (Censo Indígena 1994–1995), so having one of the two household heads answer the questions of the survey captured one of the most important decision makers of the household. If the subject knew Spanish, we did the interviews in Spanish, but if the subject was a monolingual speaker of Tsimane' we used a translator.

From the household heads, we got information on the uses of wild animals for traditional medicine and on demographic and socioeconomic attributes of that person and that person's household. From village leaders we collected information on village-level attributes, such as prices, wages, and animal abundance. Table 1 contains a complete list of all the variables we used in the statistical analysis, including definitions, number of households answering each question, and the mean, standard deviation, maximum, and minimum values for each variable. The actual data used in the analysis can be found in an Excel format on the web page of the Center for International Development at Brandeis University, which also contains the data dictionary and details of the definition and construction of variables.[1]

We express household size in adult-equivalents, and use different consumption weights from the 1.5-year study of the two Tsimane' villages. As children, women, and men consume different amounts of food owing to differences in nutritional requirements, expressing the total size of the household in adult equivalents rather than in the number of persons captures with more accuracy the total effect of household needs. To capture competence in arithmetic and in literacy we relied on people's own assessment of skills in reading and in arithmetic. In the arithmetic test we asked people whether they knew how to add, subtract, multiply, and divide, and scored each positive answer as one point. To determine literacy, we asked subjects whether they knew how to read. We opted to ask rather than to test people about their competence in arithmetic and in literacy because objective tests create tensions in a cross-sectional study; those tests are more appropriate when done with a person who has been followed over time and with whom researchers enjoy rapport. We measured income by asking about the cash value the entire household had earned from the sale or from the exchange of all goods and services during the two weeks before the interview. We measured the consumption of bush meat and wild fish consumed during the two days before the day of the interview by asking household heads about the consumption of wildlife.

In each village, we asked village leader to assess the abundance of six common wild animals to obtain a subjective measure of animal availability; from this information we constructed an index of animal abundance. The six animals included the spider monkey (*Ateles chamek* Humbolt), the giant anteater (*Myrmecophaga tridactyla* L.), South American tapir (*Tapirus terrestris* L.), white-tailed deer (*Mazama americana* Erxleben), collared peccary (*Pecari tajacu* L.), and neotropical river otter, also known as *lobito de rio* (*Lutra longicaudis* Olfers). When asked about the abundance of animals, subjects could respond "none," "few," "average," "many," "animals have never been seen," or "animals used to exist in the past, but no longer available." The response for each animal was recoded as one if village leaders said there were "many" or "average," and as zero otherwise. The recoded responses for each animal were added to arrive at an index of animal abundance that ranged from zero to six.

We also asked village leaders about other village-level information, such as the price of modern medicines, the price of game, the number of traditional and modern health workers in the village, and the prevailing wages in the village. Researchers used a Global Positioning System receiver to measure the town-to-village distance in a straight line and decided for themselves whether or not the village had access to a road.

A one-time cross-sectional survey such as the one used here will produce a lower estimate of true use if respondents feel outsiders devalue traditional medicine. Open-ended, initial questions about what animal parts people used to treat human ailments might also miss the many insects that lowland Amerindians populations have been known to use for medicines (e.g., Costa-Neto 1998; Costa-Neto and Nogueira de Melo 1998; Costa-Neto and Oliveira 2000; Marques and Costa-Neto 1997).

To analyze the information we used univariate, bivariate, and multivariate analyses. We use univariate analysis to describe the types of animals used for medicine, the animal parts used, and the ailments treated (Table 2). We use bivariate analysis to compare the socioeconomic and demographic attributes of households that reported using and not using animals for medicine (Table 3). We use multivariate regressions to estimate the correlation of selected variables on the probability of using an animal for medicine. As we shall see, many of the results from the bivariate analysis gain strength and others become weaker once we control for the role of third variables.

A multiple regression is a statistical technique in which one predicts a dependent variable as a function of several explanatory variables. We chose to use one called a probit regression, a type of multiple regression appropriate when the dependent variable is categorical. In this study, the dependent variable took the value of one if the household head said the household had used an animal part to treat an ailment and it took the value of zero otherwise. Probit regression allows us to estimate the probability that the dependent variable will take the value of one when the explanatory variable increases by: [A] one unit above its mean value or [B] when the explanatory variable increases by a half standard deviation above its mean value. In both [A] and [B], all the other explanatory variables remain constant at their mean value.

We decided to report the results of the probit regression in two forms, [A] and [B], for two reasons. First, it is customary in some social sciences to report coefficients from probit regressions when the explanatory variable increases by one unit above its mean value. Second, since the units in which we measured explanatory variables are arbitrary and differ—e.g., income is measured in *bolivianos,* age is measured in years, distance is measured in kilometers—we decided to standardize their effect on the dichotomous variable by estimating probabilities when the explanatory variable increased by a half standard deviation.

We used a probit regression to estimate the effect of explanatory variables on

TABLE 1.—Definition and summary statistics of variables used in regression analysis.

Name	Definition	Obs	Mean	Std dvt	Min	Max
Dependent variable						
Household uses medicinal animal	Household uses medicinal animal: 0 = never; 1 = at least once in memory of household head	508	0.285	0.452	0	1
Explanatory variables: community level						
Price-medicine	Bolivianos (Bs)/box of general-purpose ointment[a]	508	4.11	1.53	2	10
Price-game	Average price (Bs/kg) for the following types of game: paca, collared peccary, and white-tailed deer. For scientific name of animals, see Table 2.	508	8.73	2.95	2.67	18.33
Distance	Distance to closest town in km using Geographic Positioning System receiver.	508	33.86	23.24	0	101
Caregivers	Number of health workers in village	508	0.18	0.38	0	1
Road	1 = village has year-round access by road; 0 = otherwise	508	0.492	0.500	0	1
Animal abundance	Estimated abundance of *lobito de rio* (*Lutra longicaudis*), giant anteater, Brazilian tapir, spider monkey, collared peccary, and white-tailed deer (arbitrary scale 0–6)	508	1.94	1.95	0	6
Wage	Value of daily wage, Bs/day, with food for unskilled worker in village	508	20.90	5.864	10	50
Explanatory variables: household level						
Wildlife	Weight in kg of game and fish brought into household/adult equivalent in last two days. Adult equivalent refers assigns a higher weight to adults than to children owing to greater nutritional requirements (see Deaton 1997)	508	1.905	3.500	0	54.369
Income	Bs/adult equivalent earned from sale, wage labor, and barter in last two weeks	508	47.22	70.85	0	546
Wealth	Value in Bs of 16 assets/adult equivalent. Assets included such things as chickens, rifles, fishnets	507	600.68	445.93	70.588	3429
Household size	Adult equivalents in the household; see under variable wildlife	508	4.0	1.9	0.62	12.13

TABLE 1.—Continued.

Name	Definition	Obs	Mean	Std dvt	Min	Max
Explanatory variables: personal level						
Education	Maximum education attained (in years)	508	0.89	1.64	0	13
Arithmetic	Self-assessed ability in arithmetic: 0 = none, 1 = a little, 2 = good	507	0.317	0.589	0	2
Reading	Self-assessed reading ability: 0 = illiterate, 1 = a little, 2 = reads well	508	0.338	0.611	0	2
Age	Age in years	504	36.5	14.5	13	125
Gender	Gender of subject: 1 = female; 0 = male	508	0.48	0.50	0	1

[a] 6.03 *bolivianos* = 1 US dollar at time of field work.

the probability of using an animal for medicine. The advantage of the probit regression over a linear probability model is that the probit regression keeps values of the dichotomous dependent variable between zero and one without arbitrarily setting them there, as is the case with a linear probability model. The probit model draws on maximum likelihood to estimate the effect of regression parameters on Z scores for specific units of observations (in this case households). It then draws on the cumulative density function from the standard normal distribution to get an estimate of Pr(Y=1) conditional on changes in the underlying Z score. Two alternatives to probit models are logit and logistical models; since all three types of regression models produce similar results when estimating changes in the probability from changes around the mean value of explanatory variables, we decided to use the probit model. Aldrich and Nelson (1984) and Long (1997) provide details of how probit and logit regressions work.

Before using the probit regression we tested and rejected the assumption of constant variance in the error term at the 10% confidence level. We therefore use Huber-White robust standard errors. Robust standard errors are necessary when running a regression with heteroskedastic or non-constant error terms (Gujarati 1995). We did not have instrumental variables to control for possible biases from endogeneity or reverse causality. An instrumental variable is a variable that is highly correlated with the endogenous explanatory variable, but is uncorrelated with both the error term and with the dependent variable. Because we cannot establish the direction of causality in unambiguous ways, we speak of correlation when discussing the regression results. In the context of probit regressions, discussed later in this paper, a correlation refers to the probability of using a wild animal for medicine when the explanatory variable increases by one unit or by a half standard deviation above its mean value while holding constant all other explanatory variables at their mean value.

Since we did not collect repeated measures of people over time, we cannot control for unobserved fixed heterogeneity in endowments and preferences of people or biological attributes of villages (other than animal abundance) that could influence both the use of animals for medicine and the covariates used in

TABLE 2.—Animal part last used and ailments treated among Tsimane' Amerindians, Bolivia, 2000.

Animal	Parts	Human ailments treated
1. Brazilian tapir (*Tapirus terrestris*) (3)	fat (1)	cough (1)
	nail (1)	"bad wind" (1)
	liver (1)	general body pain (1)
2. brown agouti (*Dasyprocta variegata*) (1)	bile/gall bladder (1)	childbirth (1)
3. brown capuchin monkey (*Cebus apella*) (1)	bile/gall bladder (1)	eye infection (1)
4. collared peccary (*Tayassu tajacu*) (2)	fat (1)	cold (1)
5. common opossum (*Dipelphis* spp.) (6)	fat (6)	cut (1), fever (2), cold (2), leg pain (1)
6. giant anteater (*Mirmecophaga tridactyla*) (4)	nail (1)	general body pain (1)
	hair (2)	snake bite (1), urinary problem (2)
	liver (1)	heart pain (1)
7. jaguar (*Panthera onca*) (1)	fat (1)	cough (1)
8. kinkajou (*Potos flavus*) (1)	penis bone (1)	earache (1)
9. paca (53) (*Agouti paca*)	fat (1)	general body pain (1)
	bile/gall bladder (42)	stomach pain (1), leishmaniasis (5), snake bite (26), rheumatism (1), heart pain (1), pain in bones (2), liver pain (1), urinary (7), fever and stomach pain (1)
	teeth (8)	child birth (7), snake bite (1)
10. South American coati (*Nasua nasua*) (17)	fat (6)	cold (3), cough (2), leg pain (1)
	thorns (1)	cough (1)
	hair (2)	wounded foot (1)
	bile/gall bladder (1)	snake bite (1)
	penis bone (5)	earache (4), neck pain (1)
11. spider monkey (*Ateles chamek*) (8)	fat (2)	fever (1), cough (1)
	bile/gall bladder (5)	fever (1), cold (1), shoulder pain (2), sleeping problems (1)
	bone (1)	leishmaniasis (1)
12. stingray (*Potamotrygon* sp.) (13)	fat (10)	stomach pain (2), cold (3), cough (2), tuberculosis (1), pain in bones (1), leg pain (1)
	liver (3)	pain in bones (3), general body pain (1)
13. tortoise (*Geochelone* sp.) (3)	fat (3)	eye infection (1), rheumatism (2), headache (1)
14. white-tailed deer (*Mazama americana*) (2)	carcass (1)	cold (1)

[a] In parentheses are the number of households reporting part or ailment. Sometimes number of households under animals parts used is less than the number of households for the animal because people could not recall the part of the animal they had used. The same applies to the number of ailments mentioned and the animal part; sometimes people mentioned an animal part, but could not recall for what ailment they had used it. Sometimes the number of ailments treated with a part exceeds the number of households under "parts"; this happens when households use one part to treat several ailments.

TABLE 3.—Comparison of mean values of explanatory variables between households that used and did not use animals for medicines, Tsimane' Amerindians, Bolivia, 2000.

	Medicinal use of animals by households that					
	Did not use animals		Used animals		Test of equality of mean	
Variable	Households	Mean	Households	Mean	Statistic	p value
Price medicine	363	4.01	145	4.37	t = −2.36	0.02
Price game	363	8.7	145	8.82	t = −0.42	0.68
Distance	363	32.75	145	36.64	t = −1.08	0.09
Caregivers	363	0.16	145	0.23	t = 1.80	0.07
Road	363	0.45	145	0.6	χ^2 = 10.69	0
Animal abundance	363	1.77	145	2.38	t = −3.21	0
Wage	363	21.33	145	19.82	t = 2.64	0
Wildlife	363	1.6	145	2.67	t = 3.13	0
Income	363	41.46	145	61.65	t = −2.92	0
Wealth	363	589	144	628	t = 0.88	0.38
Household size	363	4	145	4.09	t = 0.53	0.6
Education	363	0.94	145	0.76	t = 1.14	0.25
Arithmetic	362	0.32	145	0.3	t = 0.34	0.73
Reading	363	0.34	145	0.34	t = 0.02	0.99
Age	361	35.78	143	38.43	t = 1.85	0.06
Female	363	0.49	145	0.44	χ^2 = 0.10	0.32

the analysis. For example, some villages may contain greater biological diversity and may, therefore, have greater abundance of wild animals for traditional medicine, so people in those villages may be more likely to use wild animals for traditional medicine. If we had observations over time, we could control for fixed, unseen, attributes; since we collected information only at one time, unseen fixed attributes of communities, households, and people will bias our estimates in unknown directions.

We focus our discussion of the regression analysis on results that are statistically significant at the 90% confidence level or higher. We discuss explanatory variables at the community, household, and personal levels.

Table 1 lists the explanatory variables by level. Table 4 contains the regression results; we estimate the probability that a household will use a wild animal for medicine when an explanatory variable increases while all other explanatory variables remain constant at their mean value. In column A the explanatory variables increase by one unit and the probabilities reported are the resulting marginal probabilities. For example, we know from Table 1 that the average household size in the sample was 4.025 adult equivalents; if the household size increases by one adult, then the probability that a household will use an animal for traditional medicine increases by 3.6%; results are significant at the 95% confidence level. Note that 3.6% is the *marginal increase* in the probability. In column B the explanatory variable increases by a half standard deviation and we report the *overall probability* of using an animal for traditional medicine (30.1%). Since the mean predicted probability when all explanatory variables are held constant at their mean value is 26.7% (see bottom of Table 4), a half increase in the standard

TABLE 4.—Results of multivariate regressions. Probabilities of using wild animals as medicine among Tsimane' Amerindians, Bolivia, 2000.

	Probability of using animal[1] when explanatory variable increases by following above its mean value while holding constant all other variables:	
Explanatory variable[3]	One unit [A][2]	1/2 standard deviation [B]
Price medicine	12.5*	28.5
Price game*	0.7	26.7
Distance*	−7.6**	22.5
Caregivers	7.7	28.0
Road	13.1***	29.9
Animal abundance	4.7***	31.4
Wage*	−20.7**	23.9
Wildlife	2.6	28.1
Income*	8.0**	29.8
Wealth*	4.7	28.1
Household size	3.6**	30.1
Education	−7.7***	20.7
Arithmetic	6.8	28.6
Reading	10.6	29.9
Age	0.1	27.5
Female	−2.4	26.0
Pseudo R^2	0.1	
Number of households	449	
Predicted probability at mean values of all Xs	26.7	
Probability from raw #s	145 users/508 total sample = 28.5	
Predicted probability when all Xs increase by 1/2 standard deviation	41.0	

[1] Dependent variable is binary, dichotomous categorical variable (1 = household used wild animal for medicine; 0 = otherwise).

[2] Column [A]: probit regression with robust standard errors. For units of each explanatory variable see second column of Table 1. Asterisks: *, **, and *** significant at the 90%, 95% and 99% confidence level.

[3] Explanatory variables with an asterisk (*) are in logarithms; 100 *bolivianos* added to income to avoid producing missing values when taking logarithms.

deviation of household size produces a change in the marginal probability in the use of medicinal plants of +3.37% (3.37% = 30.12%–26.75%), roughly comparable to the 3.6% of column A. The slight difference arises because the unit increase in column A (one adult) differs from the half standard deviation increase in column B (0.9 adult).

The last five rows of Table 4 contain information about the overall model. The pseudo R^2 is measure of goodness of fit of the model. The number of observations is 449, lower than the number of observations in Table 1 because of missing values that arose from taking the logarithm of the variable on wildlife consumption/adult equivalent. We re-estimated the probit models adding a constant (0.01) to households without wildlife consumption and found that the results did not change from those reported below in a significant way. The bottom three rows deserve a brief comment. The row called "predicted probabilities at mean values of all Xs" represents the overall probability (26.7%) of using an animal when all Xs are held constant at their mean value; the probability is estimated using the 449 observations used in the regression. The penultimate row represents the share of the households that used an animal for medicine and is derived by dividing the number of households that used animals (145) by the total sample (508). The last row contains the overall probability of using an animal when all explanatory variables increase simultaneously by a half standard deviation.

RESULTS

Few Tsimane' said they had used wild animals for traditional medicine. In response to the question "when was the last time you have used an animal to treat an ailment?" about three quarters of the household heads (71.4%) said they had never used an animal part to treat human ailments. In a companion study we show that the Tsimane' make widespread use of plant and plant products for many purposes, including the treatment of human illnesses (Reyes-García 2001). The same does not appear to be true with the use of animal parts.

Of the Tsimane' who said they had used a wild animal for traditional medicine, most said they had relied on only a few animals. The survey yielded a total of 14 animals used to treat human ailments (Table 2). All animals were mammals except for a stingray (*Potamotrygon* sp.) and a tortoise (*Geochelone* sp.). The mammals used belonged to five orders: Carnivora, Primates, Artiodactyla, Perissodactyla, and Rodentia. According to one source from Bolivia (Tarifa 1996), among the animals used for medicines by the Tsimane' five species are threatened or vulnerable to extinction: Brazilian tapir, spider monkey, giant anteater, collared peccary, and jaguar (*Pantera onca* L.). Of these, only the spider monkey appears in the IUCN list of vulnerable species. Although Tsimane' mentioned a total of 14 animals, four of them—paca (*Agouti paca* L.), South American coati (*Nasua nasua* L.), stingray, and spider monkey—accounted for 79.2% of all animals used. None of the Tsimane' surveyed mentioned more than one animal.

Again, this contrasts with the use of medicinal plants. Reyes-García (2001) found that Tsimane' used wild plants mostly for traditional medicine. She found that most medicinal plants had at least two unrelated medicinal uses. Out of the 169 medicinal plants registered during the longitudinal study in the two Tsimane' villages, Reyes-García found that only 27 medicinal plants had only one use, 58 had 2–3 unrelated uses, and 18 medicinal plants had at least four uses. The total number of wild animals (14) used for traditional medicine by the Tsimane' is similar to the total number of wild animals (13) used by the Kiriri Indians of Brazil (Bandeira 1972), but considerably lower than the total number of animals (50) used by the Esse Eja Indians of southern Peru (Alexiades 1999). Tsimane' used few animal parts to treat human ailment. Fat, bile, and gall bladders accounted for most of the animal parts used. Other parts included such things as teeth, livers, and bones. Tsimane' obtained fat for traditional medicine mostly from the South American coati, common opossum (*Dipelphis* sp.), tortoise, and stingray, and they obtained bile mostly from the paca and from the spider monkey.

The last column of Table 2 suggests that the Tsimane' use animal parts to treat many different human ailments. For example, the Tsimane' use the bile and gall blader from the paca to treat nine ailments. Although the Tsimane' mentioned many different types of ailments, they were most likely to have used an animal part to treat snake bites and, to a lesser extent, to treat coughs, colds, and urinary tract problems.

In Table 3 we compare the socioeconomic and demographic attributes of households that used animals for medicines and households that did not. A comparison of mean values between the two samples suggests that households that used animals for medicine lived in communities with higher price for modern medicines and were farther away from market towns. Those villages had more health care workers, animals in the commons, and lower wages, and were more likely to have access to a road. Household heads that used medicinal animals were slightly older and lived in households with more income and wealth than households that did not use animals for medicine.

The results of the multivariate regressions shown in Table 4 suggest that at the community level, animal abundance and greater access to roads correlated positively with a greater probability of using an animal for traditional medicine, but wages and distance to the nearest market town correlated negatively. A one percent increase over the sample mean of 33.85 km in the distance from the nearest market town correlated with a 7.6% ($p<0.05$) lower probability of using an animal for traditional medicine. Access to a road correlated with a 13.1% ($p<0.001$) higher probability of using an animal for traditional medicine. Last, a one percent increase in the village wage correlated with a 20.7% ($p<0.05$) lower probability of using a wild animal for traditional medicine.

We found support for the idea that animal abundance correlated positively with the probability of using a wild animal. A one-unit increase in the index of animal abundance around the village was associated with a 4.7% ($p<0.001$) higher probability of using wild animals for traditional medicine.

If we focus on the three following indicators of integration to the market—distance to the nearest town, access to roads, and wages—we find ambiguous results about how markets affect the use of wild animals for traditional medicine. If we equate integration to the market with proximity to market towns or with access to roads, we find that villages closer to towns and villages with access to roads were more likely to use wild animals for traditional medicine. The results suggest that markets correlate positively with increases in the demand for wild animals for traditional medicine. But if we equate integration to the market with wages, we find that Tsimane' living in villages with higher wages were less likely to use wild animals for traditional medicine.

Last, the sign of the coefficient for the price of modern medicine was positive, suggesting that modern medicines and wild animals for traditional medicines are substitutes. A doubling in the price of modern medicines increased the probability of relying on wild animals for traditional medicine by about 12.5% ($p<0.10$).

Two of the four household-level variables were significantly associated with the probability of using wild animals for traditional medicine. Household size correlated positively with a greater probability of using wild animals for traditional medicine. Each additional adult in the household above the 4.0 mean for the sample correlated with a 3.6% ($p<0.05$) greater probability of using a wild animal for traditional medicine. A one *boliviano* increase in income above the sample mean of 47.22 *bolivianos* correlated with a 8.0% ($p<0.05$) greater probability of using a wild animal for traditional medicine (6.03 *bolivianos* = 1 US dollar at the time of fieldwork). The result suggests that among the Tsimane' parts of wild animals used for traditional medicine may be normal goods—demand increases as incomes rise.

Last, the coefficients of personal-level variables suggest that only education correlated with a change in the probability of using wild animals for traditional medicine. An additional year of education above the sample mean of 0.886 years of education correlated with a 7.7% ($p<0.001$) lower probability of using wild animals for traditional medicine.

DISCUSSION

The central question motivating this article was: How does integration into a cash market economy with a consequent rise in cash income among households of tropical lowland Amerindians affect their traditional use of wild animals to treat human ailments? We made the point at the outset that relatively little was known about human uses of wild animals for medicines among indigenous people of the New World.

The picture of the Tsimane' that emerges from the survey is that of a tropical lowland Amerindian society in which the average household head uses only a few wild animals, to obtain only a few animal parts, to treat only a few human ailments. The finding is consistent with the low use of wild animals to treat human ailments reported by Bandeira (1972) among the Kiriri Indians of Brazil. The low use contrasts with the high use in northeast Brazil reported by Costa-Neto and his colleagues (e.g., Costa-Neto 1998; Costa-Neto and Marques 2000) and in southern Peru reported by Alexiades (1999). It also contrasts with the widespread use of wild plants to treat human ailments among the Tsimane' and other lowland Amerindian groups and with the well-documented importance of wild animals as a source of animal proteins among lowland Amerindians.

In answer to our central query of how integration into a cash market economy affects the use of wild animals to treat human ailment, a complex picture emerges. For example, we found that two proxies of a market economy—wages and schooling—correlated with a lower probability of using wild animals for traditional medicine. On the other hand, two indicators of participation in the market economy—proximity to market towns and access to roads—correlated with a higher probability of using wild animals for traditional medicine.

The findings must be read with caution owing to shortcomings in the information collected. Because we relied on a one-time cross-sectional survey, we could not control well for unseen, fixed attributes of households and people. We relied on the perception of village leaders about animal abundance rather than counting wild animals in the field. Last, we did not collect information on the actual quantity of wild animals used for traditional medicine, so we could not estimate the income elasticity of consumption—the percentage change in the consumption of wild animals for traditional medicine from a percentage change in income.

The low use of wild animals as medicines suggest that policies to enhance wildlife conservation among the Tsimane' should probably be targeted at reducing the use of wild animals as a source of food (whether by indigenous people or by outsiders) rather than at reducing the use of wild animals as a source of traditional medicine. Unlike some of the case studies of Asia and Africa reviewed earlier, among the Tsimane' the use of animals for medicine is not a significant threat to conservation.

If policy-makers decide they wish to improve the conservation of fauna by reducing the use of wild animals for medicine, then the results of this analysis hint at two possible policy options: wages and the price of modern medicines. We have presented evidence to suggest that higher wages from greater employment opportunities correlates with a lower probability that rural populations will use wild animals for traditional medicine because the opportunity cost of foraging rises. Policies geared at creating greater employment opportunities might have beneficial, direct effects on the conservation of wild animals for medicine. Similarly, we found that a doubling in the price of modern medicines correlated with an increase in the probability of using wild animals, suggesting that public health policies that deliver medicines and medical services to rural areas at lower prices will likely enhance the conservation of fauna in a direct way.

NOTE

[1] www.heller.brandeis.edu/sid/research/bolivia.asp

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